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VOLUME III: NUMBER 3 (1992)

# CSERIAC GATEWAY

PUBLISHED BY THE CREW SYSTEM ERGONOMICS INFORMATION ANALYSIS CENTER

## In this issue:



CSERIAC is a United States Department of Defense Information Analysis Center administered by the Defense Technical Information Center, Alexandria, VA, managed by the Armstrong Laboratory, Wright-Patterson Air Force Base, OH, and operated by the University of Dayton Research Institute, Dayton, OH.

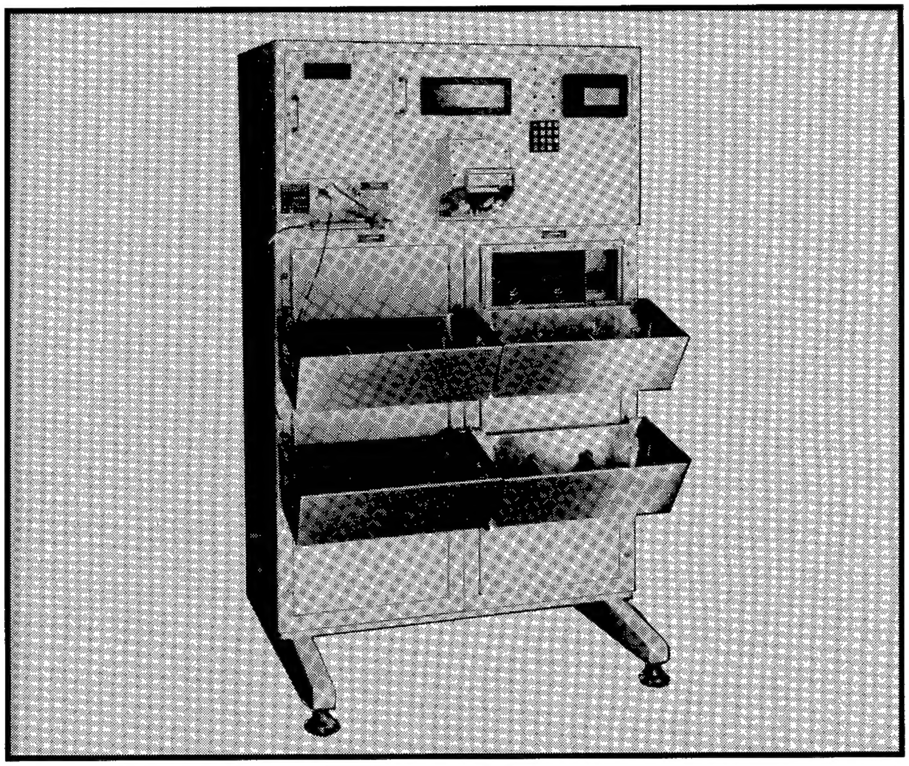

*Figure 1. The Resuscitative Fluids Production System (REFLUPS) was designed to produce water for injection and medical solutions from potable water in a field environment. Human factors engineering was applied in determining the location of maintainer accessible modules, the angle of operator information screens, and in designing the output receptacle size and location to optimize ease of use. Photo courtesy of U.S. Army Medical Materiel Development Activity, Ft. Detrick, MD.*

# Human Factors in Medicine: Quo Vadis?



**Paula M. Sind**

In 1968, Dr. Maurice Rappaport presented a challenge in an address before Division 21 (Applied Experimental and Engineering Psychologists) of the American Psychological Association. He identified five areas as prime territory for human factors engineering efforts. Since then, some of his ideas have been realized, some are in the process of being implemented, and others remain dreams. But one thing remains clear after nearly a quarter of a century: The medical arena is ripe for the infusion of human factors engineering expertise (see Fig. 1).

The United States health care system has been the subject of heated criticism that has intensified over the past decade. Costs are skyrocketing, patients are being denied treatment, legal actions against health care providers and medical equipment manufacturers are

*Continued on page 2*

commonplace, and the list goes on. Despite these criticisms, however, the standard of care in the United States is virtually unparalleled, and the life expectancy of Americans has been extended as a result of medical advances; thus all is not lost. The problems that plague the American health care system can partially be attributed to (1) health care manpower shortages; (2) shortcomings in medical education; (3) medical information and communication system deficiencies; (4) diagnostic and treatment equipment deficiencies; (5) lack of assessment of the effects of medical procedures on behavior and performance; and (6) lack of emphasis on medical technology assessment. These first five problems were among the needs identified by Rappaport (1970). Contemporary interpretations of Rappaport's needs assessment, as well as the emergence of the sixth factor are addressed in this article. Human factors implications of the observations presented by Lund (1992) concerning future combat medical support requirements will be integrated throughout.

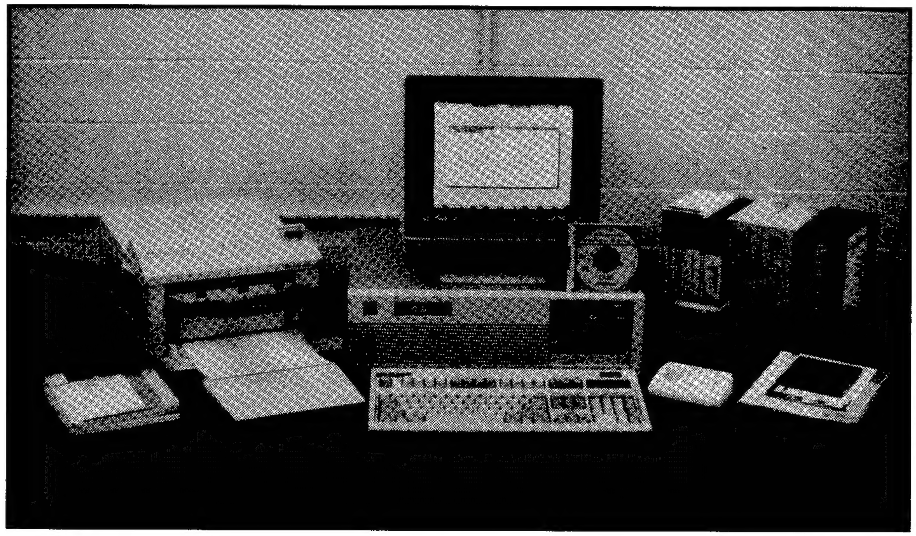

*Figure 2. The Submarine Operational Illness and Injury Contingency Management Program, dubbed Black Boat Alpha, is a computer-based information and decision support system designed for use by independent duty corpsmen aboard submarines. This system is important because space and communication with medical experts ashore are severely limited on submarines. Human factors engineering was applied in designing the human-computer interface, component integration, and usability testing. Photo courtesy of the Naval Submarine Medical Research Laboratory, Groton, CT.*

### Health Care Manpower Shortages

Physicians, nurses, skilled technicians in critical specialties—the supply of qualified practitioners in many specialty areas and geographic locations is insufficient to meet demand. The problem is not simply a matter of numbers, but one of productivity shortcomings. Rather than adding practitioners to the system (which will increase costs, as more salaries will need to be paid), an emphasis on increasing the productivity of current practitioners is more likely to yield a greater return. Rappaport (1970) stressed the need for delegation of tasks to the practitioner with the least surplus of expertise needed to accomplish them. He recommended the reassignment of some physician duties to *feldshers*, a class of medical personnel with training somewhere between that of a physician and that of a nurse. Today, we know these individuals as physicians' assistants and nurse practitioners (and their counterparts in the military community), and their existence has helped to alleviate manpower shortages in some areas. Nonetheless, the productivity of medical practitioners could be further enhanced by redesigning their tasks and the equipment they use, to promote efficiency (see Fig. 2).

It is estimated that medical personnel spend better than one-half of their time performing information collection and management tasks. Furthermore, there is substantial duplication of effort in most instances, which greatly erodes the manpower resources available. If the amount of time practitioners spent obtaining, documenting, and communicating patient data were reduced, significant savings could be realized.

Inefficiencies resulting from failed equipment also take their toll on personnel resources. Although increasing device reliability may not be within the purview of human factors engineering, increasing the reliability of the interaction between the practitioner and the device certainly is. An analysis of FDA device failure incident databases by Bassen (1986) found that 7.7-18.3% of all reports revealed "user error" as the cause of failure. Reducing incidences of user/device errors would eliminate the additional time required by medical personnel to (1) attend to automated systems that have failed, (2) restart failed devices, (3) render additional care necessitated by a failed device, and (4) attend to the documentation requirements resulting from the failure event. Not only could the quality of care be improved, but the time demands on medical practitioners could be reduced.

### Shortcomings in Medical Education

The rapid pace at which new knowledge comes into existence makes it impossible for physicians (and other medical practitioners) to stay current in their field. This is perhaps not so much a shortcoming in medical education, but a limitation of knowledge acquisition. Medical practitioners cannot continuously strive to update their knowledge, lest they have no time to tend to their patients (see Fig. 3). Rappaport (1970) called for the evaluation of training techniques and educational tools by human factors engineers as a means for increasing the effectiveness of medical education. Although this task has not been undertaken

by human factors engineers specifically, some evaluations have been conducted and some modifications to training techniques have been implemented, but questions as to the effectiveness of medical education and training remain.

Other attempts to augment the knowledge of medical practitioners continue. There has been an increasing reliance on "intelligent" aids, designed to bring the latest in medical knowledge to practitioners, coupled with information management and decision-making capabilities. Expert systems have benefitted from human factors engineering in a variety of applications areas, medicine being just one of them. Yet, there is still much more to be done. Intelligent aids can not only support medical decision-making and information management, they may also facilitate the integration of medical planning factors with operational considerations in combat situations, as recommended by Lund (1992).

The use and human-computer dynamics are critical to the ultimate utility and effectiveness of automated information and decision-aiding tools in any environment. Current limitations to the accuracy of such systems, coupled with the practical and legal ramifications of decision errors, make this a critical human factors engineering issue. As Rappaport (1970, p. 29) states, "The computer should be his aid—his idiot savant," identifying a crucial element of the interaction dynamics of medical decision aiding. Sind and Stetson (1991) called such systems "wolves in sheep's clothing," raising concerns and identifying shortcomings in the human factors engineering philosophies of expert system design for medical (and other types of) decision making. A better understanding of human/computer decision-making dynamics is needed to ensure that the computer becomes a useful assistant to the medical practitioner, rather than a sly, deceiving, and potentially dangerous "advance" that actually degrades the practitioner's performance. Appropriately designed, such systems have extreme potential to facilitate consistently good medical decisions and, ultimately, to integrate such decisions within a larger operational framework. Yet, the extent to which that potential may be realized is heavily dependent upon system design.


*Figure 3. Keeping abreast of new developments and technologies in the medical field can interfere with the medical practitioner's time for giving patient care. Illustration by Tim Span.*

### Medical Information and Communication System Deficiencies

Much effort and time are wasted due to the inefficiencies and deficiencies in medical information and communication systems. A patient's time is also valuable, and often needlessly wasted in providing redundant information about his/her medical history, or undergoing repeated diagnostic tests because the results were misfiled, located elsewhere and thus unattainable, or the conduct of prior testing was unknown to the practitioner now treating the patient because it was done in another place by someone else. More obvious, perhaps, is the compromised care that results from the lack of information when and where it is needed. Documenting a patient's allergy to a medication may prevent him from experiencing a serious reaction at a later point in time, but *only* if that record is readily accessible at the time and in the right place. Although the electronic storage and transmission of medical data and images are now possible, such capabilities have yet to be exploited. Although cost is the primary factor which has limited the adoption of advanced technologies, it is the (lack of) perceived benefit relative to cost that is perhaps more to blame.

Human factors engineering may be beneficial in helping to increase the benefits that can be actualized from advanced technologies. For example, appropriate benchmarks and minimum system requirements for electronic medical imaging systems are best psychophysically derived from systematic evaluation of image interpreter performance, rather than driven by the technology. Human factors engineers can aid in quickening the pace of performance enhancements by identifying imaging parameters for which improvement would yield not just the

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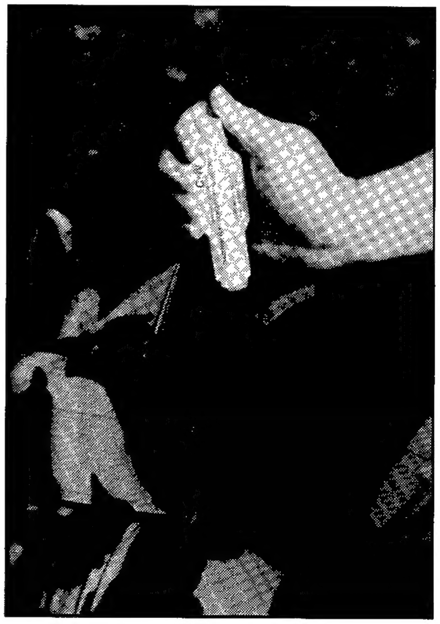

*Figure 4. The Convulsant Antidote Nerve Agent (CANA) is a soldier-carried medicament designed to reduce the effects of convulsions associated with nerve agent poisoning. Human factors engineering was applied in designing and packaging the autoinjector to make it distinguishable from other onboard injectors by feel, without the soldier having to see the item. Photo courtesy of the U.S. Army Medical Materiel Development Activity, Ft. Detrick, MD.*

greatest sensitivity gains, but those which would yield the greatest performance increment.

### Diagnostic and Treatment Equipment Deficiencies

User problems, rather than equipment malfunction, can account for half of all equipment problems in the acute care environment, and can adversely and seriously affect patient monitoring, diagnosis, and therapy (Ostrander, 1986). If a product is found to pose a serious safety concern, it may be recalled. An estimated 12% of medical device recalls are the result of "human factors problems," according to Hyman & Schlain (1986). Systematic consideration of human factors issues and comprehensive performance evaluations are needed to reduce human factors problems in medical equipment. Where equipment requirements are particularly challenging (e.g., ruggedized medical equipment for rapid, mobile deployment; equipment intended for naïve or incapacitated users as shown in Fig. 4), the importance and scope of human factors considerations are intensified.

Despite a myriad of published standards, guidelines, recommended practices, and regulations for most aspects of medical equipment design, specific human factors guidance is sorely lacking. The Association for the Advancement of Medical Instrumentation (AAMI) published the first set of guidelines for human factors engineering of medical equipment in 1988. The *Guidelines*, developed with the participation of medical device industry representatives and users, were derived from MIL-STD-1472C, several other DoD standards and resources, and suggestions of the designers and users who participated in their development. While extremely beneficial as a first effort, potential weaknesses of the AAMI *Guidelines* should be noted.

Although users contributed significantly to the development of the *Guidelines*, the users involved were, almost exclusively, anesthesiologists. As such, the homogeneity of the users involved and their input may limit the utility, applicability, and appropriateness of the *Guidelines* as applied across all types of medical equipment.

In addition, information extracted from sources such as MIL-STD-1472C was selectively "adapted," when it was felt that it was inappropriate (e.g., specifications based on anthropometric data collected from a military population). These "adaptations" were opinion-based rather than empirically based, and have not been validated. The paucity of human factors research directed toward the development of medical device design criteria and recommendations necessitated the reliance on data and criteria derived from military systems. Some validation and research directed at specific issues for medical equipment design are needed before the *Guidelines* can be adopted with confidence. Moreover, blind adherence to published guidelines does not ensure a better, safer, more productive, "human-engineered" product. Although the next revision to the AAMI *Guidelines* will include an overview of the design process with the role of human factors engineering defined throughout (adapted from military specifications and handbooks), the *Guidelines* remain just that—guidelines. Live human factors engineers need to be involved in the design and evaluation of medical devices, even when the *Guidelines* are followed. We have not yet managed to reduce human factors engineering to a cookbook that any designer can pick up and follow, and it is unlikely that we will be able to do so in the near future.

### Assessment of the Effects of Medical Procedures on Behavior and Performance

Advances in medical technology and pharmaceuticals have had exciting and beneficial effects on patients. Outpatient surgery is commonplace, and there is an emphasis on early release, home care, and self-care, primarily as cost-saving measures. Moreover, diabetes, epilepsy, allergies, high blood pressure, and other disorders that once killed or severely restricted lifestyles, are now controllable (although not necessarily curable), due to a proliferation of prophylactic and maintenance drugs. Millions of Americans now lead longer, more "normal" lives, as long as they take their medication—the consequence of which is that the number of people on medication is growing. And, while pharmaceutical manufacturers have demonstrated the efficacy and safety of their product in accordance with U.S. Food & Drug Administration requirements, the behavioral and performance implications of many of these drugs are not as well known. It is in this domain that the DoD community has led the civilian sector in research, as a result of concerns about the abilities of soldiers, sailors, and airmen to perform when sleep-deprived, subjected to the influence of various phar-

maceutical agents, or a combination of such factors. This information is equally beneficial in understanding the effects of these drugs on civilians' abilities to drive automobiles, perform the cognitive and physical requirements of their jobs, etc. Finally, those concerned with the abilities of medical personnel to remain alert, capable, and proficient over extended periods of duty need only look for advice to the DoD community, which has perhaps the longest standing and most productive program of research on the problems (and improvement strategies) of sustained and continuous operations. Continued efforts to evaluate the performance effects of specific medical procedures, pharmaceutical agents, and various medical afflictions would be quite beneficial, and should include both military and civilian populations.

**Emphasis on Medical Technology Assessment**

Technology Assessment has been an important part of the military systems acquisition process, yet it has only recently emerged as an important consideration in medical systems development and acquisition. Because medical technology assessment (MTA) necessitates a systematic rather than a piece-wise approach, the systems engineering-based philosophy of human factors engineering test and evaluation methods could be very beneficial and appropriate. Relman (1988) describes MTA as the "third revolution in health care," due to its current stance as a potential way to ensure cost effectiveness in adopting medical technology innovations. Roper, Winkenwerder, Hackbart, & Krakauer (1988) note that while MTA can provide a sound basis for economic decision making, improve the quality and effectiveness of heath care, and enhance safety for both the patient and provider, the methods of data acquisition and processing for evaluating medical technology safety and effectiveness are lacking. However, human factors engineers have been involved in related activities for non-medical systems for over half a century. Thus, filling the methodological void may not be so terribly difficult.

**Conclusions**

There continues to be a great need for human factors involvement in health care and medical applications. Medical technology is outpacing our knowledge of its effects and usability, and the military medical arena will experience very different challenges in anticipation of future combat conditions. These factors combine to make this a prime area for human factors engineering efforts. Interest in human factors in medicine has emerged over the past quarter decade and the number of human factors practitioners with active interests in this area continues to grow. In that regard, 1992 was a landmark year, as two organizations specifically devoted to this endeavor were formalized. In April, the Human Factors Society Executive Council approved a petition for the formation of a Technical Group on Medical Systems and Functionally Impaired Users. Originally founded in 1988 as the Special Interest Group on Medical Systems and the Functionally Impaired (HFSIGMSFI), the Technical Group has over 200 members. A brief article describing this new technical group and its goals follows in this issue of *Gateway*. In May, the Subgroup on Biomedical Devices of the Department of Defense Human Factors Engineering Technical Group (DoDHFETG) ratified its charter. The formation of these groups suggests that the needs in this area are finally being recognized in both the military and civilian sectors, and the prospects for advances in the future are encouraging.

*Paula M. Sind, Ph.D., is Chair of the Engineering Psychology Program at the Florida Institute of Technology, Melbourne, FL, and an Assistant Professor in the Department of Industrial Engineering and Operations Research at the University of Massachusetts, Amherst, MA. She is founding chair of the Human Factors Society's Medical Systems and Functionally Impaired Users Technical Group.*

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# New Human Factors Society Technical Group: Medical Systems and Functionally Impaired Populations

**Michael E. Wiklund**
**Lois Smith**

Demand is growing among individuals and organizations that provide health care and rehabilitation services for user-oriented devices, equipment, and processes. The heightened demand stems, in part, from an escalation in the complexity of medical technologies as well as therapeutic techniques (see fig.). In many cases, rapid technological advancement has introduced new usability problems and safety concerns. Another factor is the number of injuries and deaths which may have been prevented through better design. For example, the U.S. Government has documented 9000 cases of patient injury or death related to human error using medical and therapeutic devices since 1984. Recently, a new interest group was formed among members of the Human Factors Society for the purpose of applying human factors/ergonomics to increase the safety, usability, and efficacy of medical devices used by both health care workers and impaired persons.

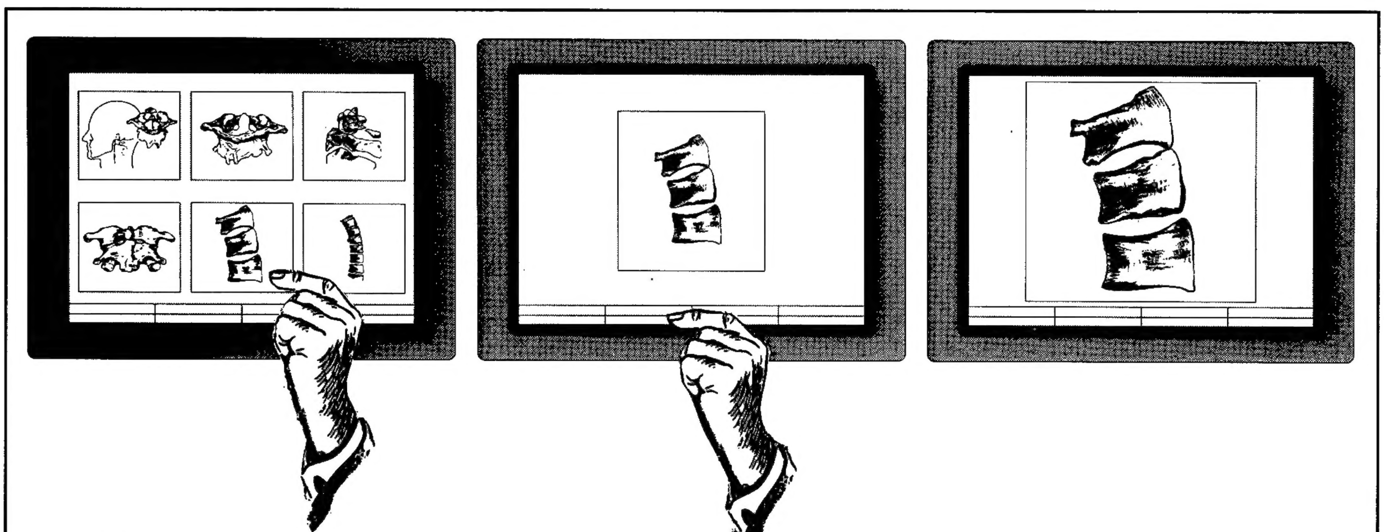
Members of the *Medical Systems and Functionally Impaired Populations* technical group are interested in improving the effectiveness of medical systems and enhancing the quality of life for people who are functionally impaired. They are also concerned with improving the interaction between care givers who use medical equipment and their patients, to reduce errors that can lead to injury and death. The Group's goals include designing and testing devices to ensure user comfort and satisfaction, adapting work environments and tools to meet peoples' needs and capabilities, and improving ways to evaluate an individual's impairment and establish an effective treatment.

Membership in the Medical Systems and Functionally Impaired Populations technical group is open to all persons who share these goals. To obtain an application, contact the Human Factors Society, P. O. Box 1369, Santa Monica, CA, 90406-1369, USA; (310) 394-1181, fax (310) 394-2410. Annual dues are $4.00; membership in the Human Factors Society is not required.

The Human Factors Society is a multidisciplinary professional organization of 5000 persons in the United States and throughout the world. Its members include psychologists, engineers, designers, and other scientists and professionals, all of whom have a common interest in designing systems and equipment to be safe and effective for the people who operate and maintain them. ●

*Mike Wiklund is the Deputy Director of the Usability Engineering Group, American Institutes for Research, Bedford, MA.*

*Lois Smith is the Publications Manager for the Human Factors Society, Santa Monica, CA.*



*Medical image workstations allow the selection of a specific organ image from all available images for that patient. These can then be manipulated, such as increased to full size. Illustration by Tim Span.*

# The COTR Speaks

**Reuben L. Hann**

Welcome readers! First I want to thank you for completing the cards indicating your wish to remain on our mailing list. Our return rate is approaching 3000 (nearly 46 percent)! This is gratifying and encouraging. However, please remember that, for the same reason, the CSERIAC Office is taking a while to process your responses. Therefore, address corrections may not appear on this issue, but should in the near future. If you have not sent in your card yet and would like to continue receiving *Gateway*, fill it out now and put it in the mail. Thanks for your interest and support.

This issue of *Gateway* features the article "Human Factors in Medicine: Quo Vadis?" Author Paula Sind reports on six areas within medicine that can benefit from human factors considerations. Five of these areas are not new, but were, in fact, addressed in 1968 by Dr. Maurice Rappaport in an American Psychological Association address. Paula discusses how human factors have influenced these areas and she points the way to the future role of human factors in medicine.

Incidentally, as Paula's article was being prepared, the Human Factors Society Executive Council approved the creation of a new Technical Group, Medical Systems and Functionally Impaired Populations. Michael Wiklund, a member of this technical group, and Lois Smith, Publications Manager for the Human Factors Society, have written a brief article on it.

As the Armstrong Laboratory Colloquium Series: The Human-Computer Interface continues, we hosted James Reason of the University of Manchester, UK, as the third guest speaker. He addressed the topic of multi-disciplinary factors underlying human error. He prepared a synopsis of his lecture, which appears later, and it is followed by excerpts from a long conversation I had with him after the lecture.

Bruce McCommons, U.S. Army Human Engineering Laboratory, provided an article on SCOPE, a recently developed software package which greatly simplifies the preparation of the Request for Proposal (RFP), a document package with which practically all DoD employees are familiar. Its components include SOW-Maker, CDRL-Maker, and SPEC-Maker. Two of these, CDRL-Maker and SPEC-Maker are mature products, available through CSERIAC.

Dave Post of the Armstrong Laboratory has written an article on a recent book, *Color in Electronic Displays.* Dave, a well-known vision expert, was an editor and authored two chapters for this book. It is available through CSERIAC for $45.

*Gateway* has a circulation of about 7000 and is sent to more than 30 countries. If you have an idea for an article which might be of interest to this general, international human factors/ergonomics community, please contact me or the editor, Jeff Landis. ●

*Reuben "Lew" Hann, Ph.D., is the Contracting Officer's Technical Representative (COTR) who serves as the Government Technical Manager for the CSERIAC Program.*

# Calendar

**August 29-September 1, 1992**
**Cambridge, MA, USA**
16th Annual Conference of the Association of Driver Educators for the Disabled, at the Hyatt Regency. Contact Victoria Swanson, 4814 W. Mountain View, Glendale, AZ 85302; (602) 435-9704.

**October 25-28, 1992**
**Hamilton, Ontario, Canada**
Human Factors Association of Canada/Association canadienne d'ergonomie 25th Annual Conference, "The Economics of Ergonomics," at the Hamilton Convention Centre. Contact HFAC/ACE, 6519B Mississauga Rd., Mississauga, Ontario L5N 1A6; (416) 567-7193, fax (416) 567-7191.

**April 18-21, 1993**
**Oak Ridge, TN, USA**
American Nuclear Society meeting, "Nuclear Plant Instrumentation, Control, and Man-Machine Interface Technologies," cosponsored by the Human Factors Division of the ANS, the HFS Smoky Mountain Chapter, and others. Contact Bill Knee or Jim White, Oak Ridge National Laboratory, P. O. Box 2008, Oak Ridge, TN 37831-6360; (615) 574-6163 (Knee), (615) 574-5592 (White), fax (615) 574-9619. *Summary deadline: August 1, 1992.*

**October 12-16, 1992**
**Atlanta, GA, USA**
36th Annual Meeting of the Human Factors Society, hosted by the HFS Atlanta Chapter, at the Westin Peachtree Plaza Hotel. Contact HFS, P.O. Box 1369, Santa Monica, CA 90406-1369; (310) 394-1811 or 394-9793, fax (310) 394-2410.

**January 4-7, 1993**
**Orlando, FL, USA**
International Workshop on Intelligent User Interfaces, sponsored by ACM SIGCHI and SIGART in cooperation with AAAI and the British HCI Group, at the Buena Vista Palace Hotel, Walt Disney World Village. Contact William Hefley, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, PA 15213; (412) 268-7793, Email: ii-Workshop93.chi@xerox.com. *Deadline for papers: July 17, 1992.*

**April 26-29, 1993**
**Knoxville, TN, USA**
5th Topical Meeting on Robotics and Remote Handling, sponsored by the American Nuclear Society, Oak Ridge/Knoxville Section, and the ANS Remote Systems Technology Division, at the Holiday Inn World's Fair and Exhibition Center. Contact the Topical Meeting on Robotics and Remote Handling, P.O. Box 200001, Oak Ridge, TN 37831, or Norbert Grant, (615) 574-4530, fax (615) 574-4624. *Abstract deadline: July 1, 1992.*

Notices for the calendar should be sent at least four months in advance to:
CSERIAC Gateway Calendar, CSERIAC Program Office, AL/CFH/CSERIAC, Wright-Patterson AFB, OH 45433-6573

# Announcements

### Online Searching with DGIS and SearchMAESTRO

With hundreds of online databases available, each with its own logon procedure and search language, finding and processing needed information can be overwhelming. The Defense Technical Information Center (DTIC) is offering two systems to help with such online searching.

The Department of Defense Gateway Information System (DGIS) provides access to 20 different online systems with more than 900 different databases. By supplying DTIC with personal account information, DGIS automatically dials and logs onto the selected online system. DGIS can search more than one database at a time, and includes powerful post-processing tools that allow users to reformat and analyze citations in many ways. These features include the elimination of duplicate citations, the ability to merge multiple files into one, sort citations by almost any field, analyze citations, and cross correlate fields. DGIS will arrange citations from BRS, DIALOG, DROLS, NASA/RECON, and ORBIT into the format specified by the user. In addition, DGIS provides access to an electronic mail module through the Internet and DDN system.

SearchMAESTRO (Menu-Aided Easy Searching Through Relevant Options) is designed to help novice users conduct their own online database research. End users may easily access 13 different online systems with more than 850 total databases by using this menu-driven system. SearchMAESTRO will even select the appropriate database for a given search strategy if one is not otherwise indicated. In addition, there is no need for separate accounts with each database vendor; even if the user searches all 850 databases available to SearchMAESTRO, there is only one bill.

For more information call Ms. Patricia Tillery at (703) 274-6434 or DSN 284-6434 or write to: Defense Technical Information Center, DGIS/SearchMAESTRO Information, Cameron Station, Building 5, Alexandria, VA 22304-6145.

### Decrease in CSERIAC SOAR Charge

CSERIAC has periodically published state-of-the-art reports (SOARs) on a variety of topics relevant to the human factors community. It has been CSERIAC's intent to simply recover costs incurred for production of these SOARs. However, the high cost of contracting various experts to write these, combined with the high cost of printing, has resulted in SOARs that were priced beyond what most ergonomists, psychologists, designers, and engineers could afford. To make the CSERIAC SOARs more readily available to professionals in the field, the CSERIAC Program Office has decreased the price from $75 to $35, effective immediately. This price reduction will apply to SOARs already published as well as future SOARs, until further notice.

### Certification For Ergonomists and Human Factors Professionals

The Board of Certification in Professional Ergonomics is now accepting applications for professional certification of ergonomics and human factors practitioners. Applicants should have a mastery of ergonomics knowledge and methods, as well as expertise in the analysis, design, and evaluation of products, systems, and environments for human use. Qualified applicants may choose to be certified as either Certified Professional Ergonomists (CPE) or as Certified Human Factors Professionals (CHFP). Applications are available from: Board of Certification in Professional Ergonomics, Office of the Executive Director, P. O. Box 2811, Bellingham, WA 98227-2811 USA, phone: (206) 671-7601 fax: (206) 671-7681.

Minimum qualifications are an MA/MS or equivalent in ergonomics or a closely related field and 7 years of demonstrable experience in the practice of ergonomics. Applications are open to ergonomists internationally.

Certification will be based on an evaluation of work samples and supporting documentation through December 31, 1993. The application processing fee is US $200 (nonrefundable) with an annual renewal fee of $75. After December 31, 1993 applicants will be required to pass a written examination.

The Board of Certification in Professional Ergonomics was formed as a nonprofit corporation in 1990. Although the Board was established with support from the Human Factors Society, it is independent of any professional, scientific, or trade association.

Current members of the Board are Alphonse Chapanis, Ph.D; David Meister, Ph.D.; Melvin H. Rudov, Ph.D.; Hal W. Hendrick, Ph.D.; George A. Peters, J. D.; H. Harvey Cohen, Ph.D.; David J. Cochran, Ph.D.; Jerry R. Duncan, Ph.D.; Steven M. Casey, Ph.D. The Executive Director is Dieter W. Jahns, M.S.

### Liveware Survey Progressing

Liveware is the term used by NATO Research Group (RSG.21) to describe Human Systems Integration tools and databases. The Liveware survey was described in the March-April 92 issue of *Gateway*. Thanks to a good initial response, we now have over 178 Liveware tools and databases listed in the Liveware database. While the Liveware database contains many human factors tools, we believe that we're just scratching the surface. If you are the developer, owner, or a major user of a Manpower, Personnel, Training, Safety, Health Hazard, or Human Factors Engineering tool, technique, database, or laboratory/test facility that can be used during systems acquisition, the sponsor, Lt. Col. Mike Pearce of the OASD (FM&P)/R&R(TFR) Human Systems Integration Office, urges you to participate in the Liveware Survey. Please phone, fax, or E-mail us to receive your copy of the survey in paper or DOS computer disk copy. The completed Liveware project should be a great help to all who attempt to consider and integrate human issues during the acquisition process. In addition, your participation will give notice to the "acquisition world" of your tool or database.

Dr. Mona J. Crissey, Defense Training and Performance Data Center, 3280 Progress Drive, Orlando, FL 32826-3229, Phone: 407-218-3743, FAX: 407-282-8922, E-Mail: TPDC047@TPDC. Navy.MIL.

or Frank C. Gentner, AL/CFH/CSERIAC, Wright-Patterson AFB, OH 45433-6573, Phone: 513-255-4842, DSN: 785-4842, FAZX: 513-255-4823, E-Mail: FGentner@Falcon.AAMRL.WPAFB. AF.MIL.

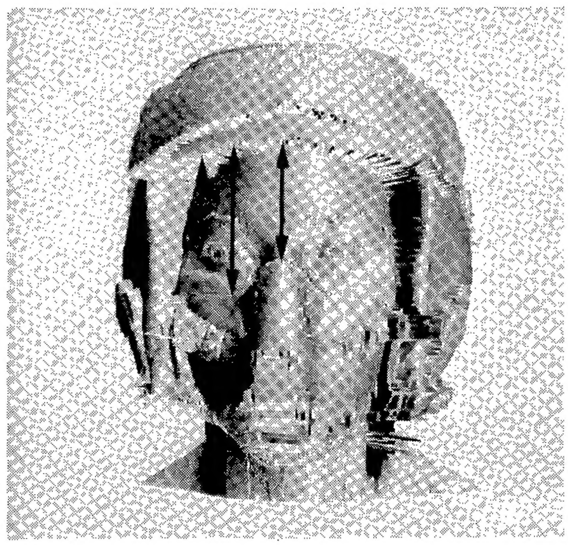
Dr. Mona Crissey is the Liveware Program Analyst at the TPDC.

Frank Gentner is the CSERIAC Senior Technical Analyst assisting in this study.

# Short Course ENGINEERING ANTHROPOMETRY October 21-22, 1992

## COURSE DESCRIPTION

This course will include description and demonstration of anthropometric measurement technologies, both traditional and new, 3-D surface-digitizing technologies, training in the use of the on-line Computerized Anthropometric Research and Design (CARD) database, training in statistical methods for design applications, a review of methods for applying anthropometry to the development and testing of protective equipment and clothing, and an introduction to the use of multivariate techniques for determining body size accommodation in cockpits. The course fee includes the connection fee for accessing the CARD Database at Level 1, and all students will have access to that resource upon completion of the course.



## COURSE INSTRUCTORS

***Kathleen Robinette*** is program manager and senior technical expert for exploratory development efforts for the USAF in anthropometry, and its application to the design and evaluation of protective equipment and clothing. She is one of the leading national experts in anthropometry with fourteen years of practical experience. She holds a B.A. in Anthropology, an M.S. in Statistics, and is a Ph.D. candidate in Biostatistics at the University of Cincinnati. While at the Armstrong Laboratory she managed the development of an automated 3-dimensional human body digitization system. She pioneered the development of anthropometrically based sizing systems and quantitative fit evaluation procedures that are being adopted by the Department of Defense and by industry as well. As the USAF representative to a multi-national standards organization, she was instrumental in the development of an international standard for anthropometric measurement.

***Greg Zehner*** is the USAF focal point for the application of anthropometric data to the design and evaluation of aircraft crewstations. He has eleven years of practical experience in anthropometry and holds a B.S. in Anthropology and an M.A. in Physical Anthropology. He has developed multivariate anthropometric techniques for specifying cockpit accommodation, which are being used in all new USAF aircraft procurements. He has also developed applied techniques for evaluating and determining the limits of anthropometric accommodation in cockpits.

- **LOCATION:**
  Armstrong Laboratory,
  Crew Systems Directorate,
  Human Engineering Division,
  Wright-Patterson Air Force Base, OH

- **DATE:**
  October 21-22, 1992

- **COST:**
  U.S. Government Employees $250
  Non-government Employees $500

- **DEADLINE FOR REGISTRATION:**
  October 9, 1992.
  Course will be limited to 30 attendees

- **FOR MORE INFORMATION CONTACT:**
  Wes Grooms, Course Administrator
  CSERIAC Program Office
  (513) 255-4842

## Armstrong Laboratory Colloquium Series

# Human-Computer Interaction is not Enough: Considering Multi-Disciplinary Factors Underlying Human Error

**James Reason**

*Editor's note: Following is an abstract based on Dr. Reason's presentation as the third speaker in the Armstrong Laboratory Colloquium Series: The Human-Computer Interface. Dr. Aaron Schopper, CSERIAC Chief of Technical Services and Analyses, edited this abstract which was prepared by Dr. Reason.*

The past few decades have seen radical changes in the relationship between complex technological systems and the people who nominally control them. Systems have become more automated, control has become more centralized in the hands of fewer operators (often remote from the process), systems have become more complex (i.e., more interactive and tightly coupled) and more dangerous (i.e., bigger inventories, more potential victims), and systems have incorporated many defenses against both human and technical failures.

These changes have substantially lessened the risk of disaster due to any single failure, either technical or human. But it renders these systems prey to "organizational accidents" due to the insidious accumulation of latent failures, some of which may have accrued over long periods of time.

In the past few years, there have been a number of "organizational accidents" affecting a wide range of systems: nuclear power plants (Chernobyl), chemical process plants (Bhopal), aircraft (Kegworth), ro-ro ferries (Zeebrugge), spacecraft (Challenger), oil rigs (Piper Alpha), railways (Clapham) and football grounds (Hillsborough). Although the surface features of these accidents are quite different, they share a number of common properties: they occurred in well defended, complex socio-technical systems; the root causes were present long before the accident sequence began; they were caused by human rather than technical failures; and they were all multiple-cause accidents.

These disasters indicate the need to distinguish between two kinds of human failure: active failures (those wherein errors and violations at the "sharp end" have an immediate impact upon the integrity of the system), and latent failures (those involving delayed-action failures that may lie dormant for a long time before they interact with active failures and local triggers to breach or bypass the system's defenses).

Latent failures are likened to resident pathogens in the human body. They cause illness through the unforeseen interaction of several factors, each necessary, but no one sufficient to bring about a catastrophic breakdown. But whereas active failures and local triggers are hard to anticipate, pathogens can be assessed proactively. Efforts at identifying and eliminating pathogens are likely to be more cost-effective than trying to prevent active failures.

The causes of "organizational" accidents may be broken down under four headings, working backwards from the accident event: failed or absent defenses, unsafe acts, errors or violations, and organizational processes.

Errors and violations have different psychological origins and different remedial implications. Task and environmental conditions are likely to promote errors and violations. Whereas a great deal is known from the human factors literature regarding error-producing conditions, we can still only speculate about the factors promoting violations. But they likely will have to

**Organizational Failure Types**

- Incompatible goals
- Organizational deficiencies
- Inadequate communications
- Poor planning and scheduling
- Inadequate control and monitoring
- Design failures
- Unsuitable construction or materials
- Poor procedure
- Inadequate maintenance management
- Poor training (and selection)

do with social and motivational factors: beliefs, attitudes, norms, perceptions of risk, safety culture, etc.

Organizational-process-related contributions to—or "causes" of—accidents may be complex and difficult to disentangle. All technological organizations are involved in designing, building, operating, maintaining, communicating, managing, organizing, and setting goals. All these processes are likely to involve fallible decisions giving rise to the 10 basic organizational failure types (OFTs) cited in the table.

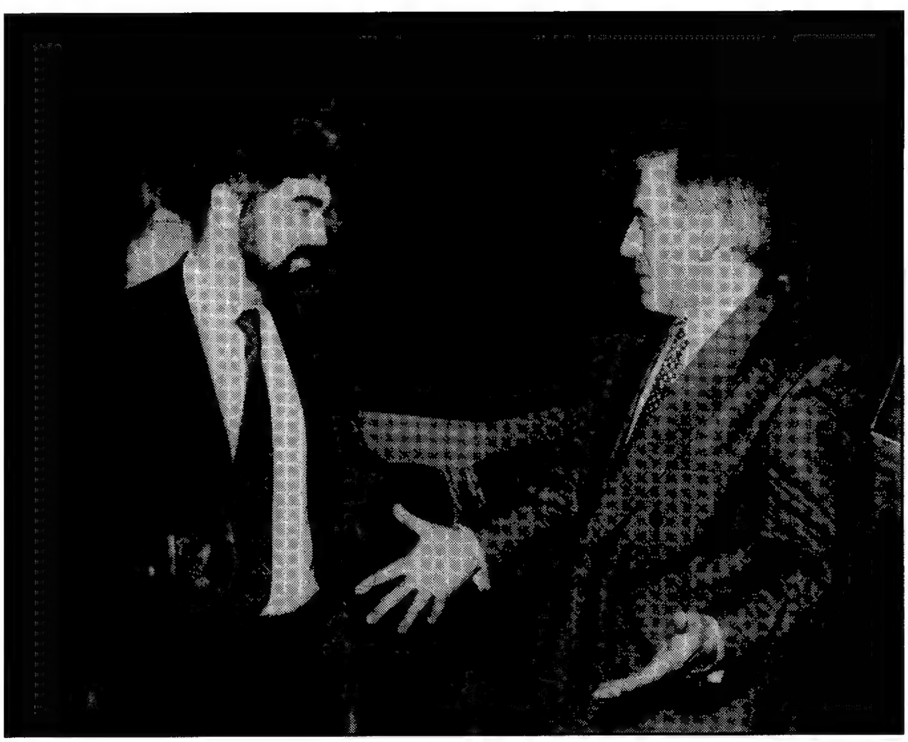
The view of accident etiology that has been described has two practical implications: (1) it provides a principled basis for backtracking from the accident event to the latent causal factors, and, more important, (2) it directs the regular monitoring of "vital signs" at different levels of the organization. These reactive and proactive measures are being applied (or will be) by a variety of organizations, e.g., oil exploration and production companies (Shell International), railway operations (British Rail), aviation engineering establishments (British Airways), and nuclear power plants (U.S. Nuclear Regulatory Commission).

In summary, in an age of increasingly complex technologies, it is rare that an accident can be attributed to a single proximate "cause." Accordingly, efforts to diagnose and discern possible contributing factors—and the error-producing potential of their interactions over time—are becoming equally demanding in terms of both the breadth of factors that must be considered and the levels of complexity and sophistication required. Albeit the computer proliferates in the environments of "high tech" organizations, and the design of the human-computer interface (HCI) is an important issue, to focus upon the HCI as the area of principal concern is simply "not enough." ●

*James Reason is a Professor of Psychology at the University of Manchester, Manchester, United Kingdom.*

## *Scenes from the Armstrong Laboratory Colloquium Series:*

*Dr. Reason making a point about the types of human errors frequently made. Photo by Dan Churchill.*



*Dr. Reason talking with Dr. Kenneth R. Boff, Chief of the Human Engineering Division and sponsor of the Colloquium Series, following the lecture. Photo by Dan Churchill.*

## Armstrong Laboratory Colloquium Series

# A Conversation With James Reason

**Reuben L. Hann**

*Editor's note: The following is an edited transcript of a conversation with Dr. James Reason, University of Manchester, UK, who had just made a presentation as the third speaker in the Armstrong Laboratory Colloquium Series: The Human-Computer Interface. The interviewer was Dr. Lew Hann, CSERIAC COTR.*

**CSERIAC:** The problem of human error has become an especially "hot" topic in the last few years. How long have you been interested in the problem?

**Dr. Reason:** I have been involved with human error and related areas since 1962—more than thirty years. The first ten years were involved with the study of spatial disorientation and motion and space sickness—sensory error, if you will. I spent several years in the late sixties working on these problems with NASA at Pensacola. I then got interested in the problem of aircraft accidents. I noted that the incidents reported as being due to human error seemed to fall into two categories. In one kind, the pilot seems to have pulled the wrong lever or to have thrown the wrong switch; that is, the "plan" was good, but there was a deviation from the intended behavior. In a large group of other cases, the pilots seem to have made a fundamental misjudgment about their capabilities and about the weather. That is, they had a bad plan.

**CSERIAC:** Could you expand a bit about how this relates to human error in the more general sense?

**Dr. Reason:** Well, one working definition of error is that an error occurs when planned actions fail to achieve their intended goal, where those deviations are not due to something like misfortune or "acts of God." The error can occur two ways. In the first case, you can have an excellent plan, but actions fail to follow the plan. The other is that you have a poor plan and the actions do follow the plan. The first we call *slips* or *lapses*; the latter are *mistakes*, where there has been a problem assessing the information and judging possible outcomes.

**CSERIAC:** Findings from accident investigations seem to be showing an increasing tendency to blame the incident on "human error." Do you think this is just a convenient way to divert blame from more fundamental system design flaws?

**Dr. Reason:** The term "human error" is, in a sense, an institutional cop-out. It allows the organization to say that this person deviated from established procedures. The problem is, of course, that "error" is a catch-all term. I think it is important to distinguish between *errors* and *violations*. They are both potentially unsafe acts, but errors have to do with information-processing problems, while violations are deliberate deviations from safe operating procedures—for what seemed like a good idea at the time. For example, analysis showed that there were seven unsafe acts at the Chernobyl accident. Probably two were errors; the rest were violations. From a psychological point of view they have quite different mechanisms, and from a remediational point of view they have very different means of trying to correct them. So the distinction is quite important.

Returning to the question of blame, one of the things that the aviation industry is becoming aware of now is that cockpits are "booby-trapped"; that is, pilots and aircrew are often the inheritors of latent failures in the system, rather than the instigators of the accident directly themselves. Most of the work I have been doing the past few years is to investigate the large-scale "organizational" accidents—ones in which the precursors can be traced back in the organizational chain. The *Challenger* accident is one such example.

**"One of the things that the aviation industry is becoming aware of now is that cockpits are 'booby-trapped'; that is, pilots and aircrew are often the inheritors of latent failures in the system, rather than the instigators of the accident directly themselves."**

**CSERIAC:** As you know, we here at Armstrong Lab are very interested in human-computer interface design issues. Could you say a bit about how your work might relate to this area?

**Dr. Reason:** Certainly our work in errors is directly related. We tried to identify the basic cognitive processes that lead to error. Errors tend to be shaped by two "primitives" in retrieving knowledge. The first matches like to like: the representativeness heuristic or similarity bias. In the other case, where the conditions in the world match more than one schema, the potential conflict tends to be resolved in favor of the most frequently encountered version. Errors tend to occur under conditions of "underspecification" of mental operation. Underspecification can occur

in several ways. For example, you can have incomplete knowledge or impoverished sense data, you can be inattentive at some critical point in an action sequence, you can be stressed and have working memory preempted by other matters, or any of dozens of other possible forms of mental operation underspecification. The outcome of all this is rather stereotypical: the system tends to default to something which is contextually appropriate and tends to be the high-frequency option. It seems to me that an understanding of this basic error-producing dynamic is quite important for designers, because when you design an interface you must be aware of the sorts of things which will provoke error.

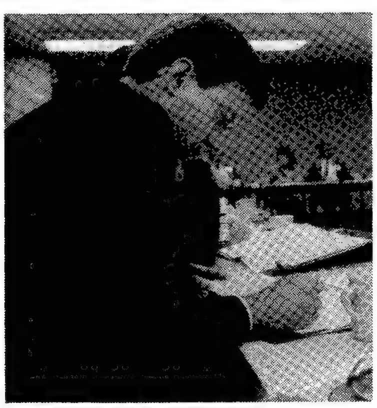
The goal of an error theory is to state under what circumstances an error will occur, and, given those circumstances, what kind of error—qualitatively—you might expect to find. These predictions can be quite powerful, if banal. I might, for example, predict that in January 1993 you will probably be writing checks with 1992 on them. While this may seem obvious and trivial, it is really very powerful. It says that erroneous actions tend to be strong habit intrusions, well-rehearsed coherent pieces of action that simply were not appropriate at the time. The same thing applies to *mistakes*, I would argue. The first of these is *rule-based*, where you have some pre-packaged knowledge of problem solutions, but where you make an error either by misapplying a good rule (applying brakes while on ice). or by applying a bad rule that somehow found its way into your repertoire. The other kind of mistake is *knowledge-based*; it occurs when you have no applicable rules, when you are thinking "on-the-fly." Humans are put in complex systems to handle just these sorts of situations, but the fact is, they are not very good at it. I think that one can say that, where people are underspecified, either as a consequence of not being able to see all of the problem space, or not having complete information, then there is a tendency to make stereotypical, conventionalized responses. ●

## Request for Topics For State-of-the-Art-Reports (SOARS)

CSERIAC makes every effort to be sensitive to the needs of its users. Therefore, we are asking you to suggest possible topics for future SOARS that would be of value to the Human Factors Ergonomics community. Previous SOARs have included *Hypertext: Prospects and Problems for Crew System Design* by Robert J. Glushko, and *Three Dimensional Displays: Perception, Implication, Applications* by Christopher D. Wickens, Steven Todd, & Karen Seidler. Your input would be greatly appreciated. We are also looking for sponsors of future SOARs. CSERIAC is a contractually convenient, cost effective means to produce rapid authoritative reports.

Send your suggestions and other replies to Dr. Lawrence Howell, Associate Director CSERIAC Program Office, AL/CFH/CSERIAC, Wright-Patterson AFB, OH 45433-6573.

# CONFERENCES MADE EASY



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# SCOPE Delivers First Products

**R. Bruce McCommons**
**Robert K. Cofod**

One of the most important things that human factors engineers are asked to do in support of system acquisitions is to provide input to the Request for Proposal (RFP). While sometimes underestimated, the importance of doing this job right is critical because the RFP is the precursor to a contract and contractors can only be expected to do what they get paid for. Simply put, if it isn't in the contract, it won't be done. Thus, if Human Factors Engineering (HFE) program and design requirements are not properly established in the RFP, they will not be incorporated in the final contract and will probably not be reflected in the system design.

Unfortunately, doing the job right is extremely difficult because it requires knowledge in so many different areas. As a minimum, in addition to having HFE expertise, one must also be well-versed in DoD materiel acquisition policies and procedures, Government procurement regulations, specification practices and data management procedures, basic contract law, and, in general, how an RFP is constructed.

Such diverse knowledge is required because, to be considered complete, an RFP package would have to include the following: definition of how the system is to look and act (i.e., the system specifications); a description of the work the offeror would be required to do to ensure that the system looks and acts as specified (i.e., the Statement of Work [SOW]); a compilation of the data required to support the various HFE program activities (i.e., the Contract Data Requirements List [CDRL]); instructions on how an offeror's proposal will be evaluated (i.e., SECTION L); and a definition of the evaluation factors for award and their relative weighting (i.e., SECTION M). Last, but not least, all the various inputs must be coherent, unambiguous, and consistent with one another because any error, contradiction, or omission can have serious ripple effects.

Realizing the complexities of crafting a model RFP, the U.S. Army Human Engineering Laboratory (HEL) initiated a program designed to make the job much easier. This program was started about three years ago and has come to be known as SCOPE, for Smart COntract Preparation Environment.

From its beginning, the SCOPE program had two thrusts. The first was to develop technology that could reduce the engineer's knowledge needs outside the human factors technical area. As implemented, this effort encompassed the uses of artificial intelligence, knowledge-based and expert systems, and object-oriented design and programming. Included in this process was the collection of data from subject-matter experts regarding what human factors engineers actually "did" in support of a system development and under what circumstances. Also included was knowledge engineering regarding the content of the various parts of the RFP and their interrelationships.

The second thrust focused on using the emerging technology to develop tools to simplify and expedite the process of preparing the RFP. As a result, three products have been completed so far. The first, *SOW Maker*, is used to produce an SOW based on user inputs describing various system characteristics. User inputs are made by responding to a series of prompts regarding the acquisition phase, what the system does, how it will be used and in what environment, and the existence of any special functional or design concerns. Each of these prompts is essentially a "trigger" that enlivens a piece or pieces of text for incorporation as work statements and, depending upon the combination of triggers selected, the permutations of these text objects can become almost infinite. After the user has responded to all the system prompts, SOW Maker assembles the operative text objects and outputs a draft SOW. Should this draft not be completely acceptable as is, it can be edited using standard word-processing procedures.

The second product, *SPEC Maker*, facilitates the tailoring of two commonly used HFE design standards (i.e., MIL-STD-1472D [Human Engineering Design Criteria for Military Systems, Equipment and Facilities] and MIL-STD-1474C [Noise Limits for Military Materiel] for incorporation in the system specifications). By navigating through a series of display screens which depict the table of contents of the two documents (see Fig. 1), the user selects the design criteria applicable to the system being procured. Once the user has finished making these selections, SPEC Maker automatically generates inputs for the three required sections of the system specifications (i.e., SECTION 2, APPLICABLE DOCUMENTS; SECTION 3, REQUIREMENTS, and SECTION 4, QUALITY ASSURANCE PROVISIONS). Should the user wish to modify these inputs, changes can be made using standard

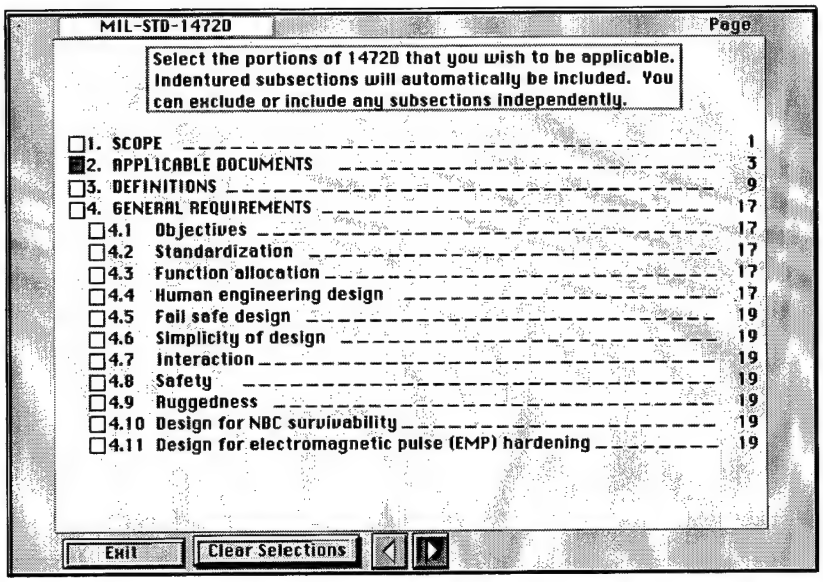



*Figure 1. SPEC Maker: initial MIL-STD-1472D selection screen.*

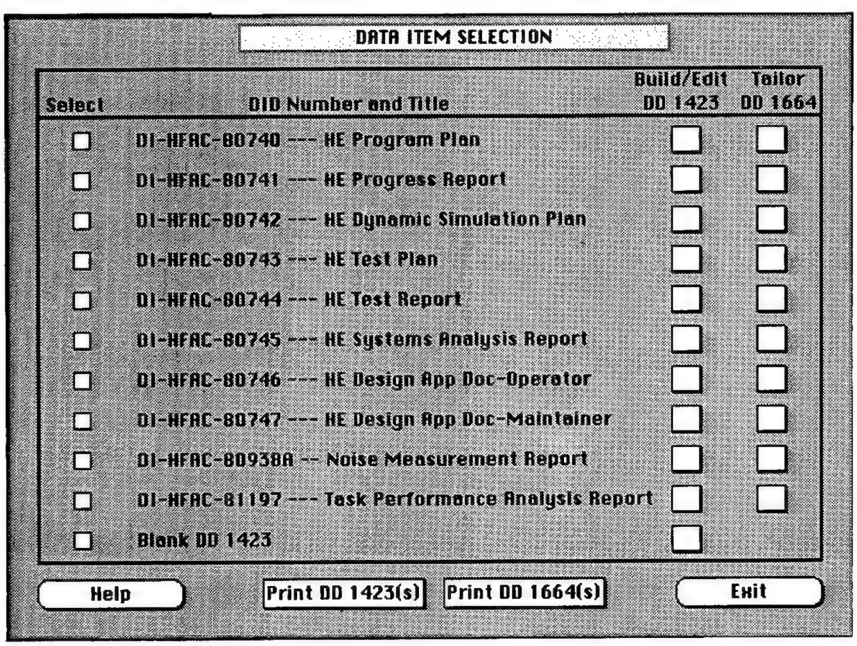



*Figure 2. CDRL Maker: data item selection screen.*

word-processing techniques.

The third product, C*DRL Maker*, takes all the work out of preparing the dreaded DD Forms 1423, the Contract Data Requirements List. It also facilitates tailoring of the human engineering Data Item Descriptions (DIDs), DD Forms 1664.

Embedded in CDRL Maker are DD 1423 templates for the 10 HFAC data items and the DIDs themselves (see Fig. 2). Once a data item is selected, the user is presented with a graphical representation of a DD 1423 with most of the required blocks already completed. If this defaulted information is not considered appropriate, the user can change it through the use of field-sensitive, pull-down menus that contain all the currently legal entries. Alternatively, the user can type directly into any of the data fields using standard word-processing procedures. Once the user is satisfied with all the entries, an exact hard copy 1423 printout can be obtained from a laser printer. CDRL Maker also allows the user to display, edit, and print any of the HFAC DIDs.

**S**PEC Maker and CDRL Maker are mature products, come with user's manuals, and are presently being offered to the public through CSERIAC. While a powerful tool, the prototypical version of SOW Maker is not being made available except for demonstrations because it relies on proprietary software and requires an expensive hardware key to run. However, a new version is presently being developed which will not have these shortcomings and is expected to be ready before the end of the year. Anyone wishing to see the prototype should contact the principal author at the U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, MD 21005-5001, (410) 278-5175.

Future plans for SCOPE include the development of tools for the preparation of the RFP Sections L and M and the expansion of SCOPE into the other five domains of MANPRINT. As new products are developed, HEL plans to

*Continued on page 18*

# CSERIAC TECHNICAL SUMMARY AND ANALYSIS SERVICES


### What is a Technical Inquiry?

Simply stated, a technical inquiry is a request for ergonomics information. In general, ergonomics information is technical knowledge about human abilities and performance, which can be used to enhance equipment design and development.

CSERIAC 's answer to inquiries can take many forms, including customized bibliographic searches, review and analysis of research, recommendations based on analyses, and expert consultation referrals. We have grouped these into three basic categories, based on the kind and amount of ergonomics expertise applied to the problem. The three categories are Search and Summary, Review and Analysis, and Technical Area Tasks. A fixed fee has been established for the first two; Technical Area Tasks must be negotiated on an individual basis.

### Search and Summary

Search and Summary consists of a literature search and a printout of relevant abstracts, which are then bound in a booklet. A professional human factors analyst reviews the abstracts and identifies the most pertinent. The human factors analyst also consults references within CSERIAC's immediately accessible resources and provides comments and/or excerpts from these references. The main purpose of this level of response is to provide a very rapid response to requests for technical information.

### Review and Analysis

This level of response includes all of the above plus direct contact with subject-matter experts, a 3-to-7 page white paper synthesizing the results of the technical review, complete copies and/or excerpts from relevant documents, and names, addresses, and telephone numbers of subject-matter experts. It also includes the requisite materials for access to databases and personal contact with the subject-matter experts. The main purpose of this level of response is the in-depth synthesis of the literature with the formation of an authoritative "conclusion" or answer regarding the question posed.

### Technical Area Tasks

In this category are those inquiries requiring major CSERIAC time and material expenditures, such as preparation of state-of-the-art reports (SOARs), critical reviews, technical assessments, and handbooks, organizing workshops and symposia, or exercising computer models in our technology transfer inventory. The main purpose of this level of response is an extensive customized effort directed at solving the customer's particular needs.

## Previous TOPICS

- Pilot Decision-Making Under Stress
- Speech Synthesis and Recognition
- Human Tolerances to Impact
- Operator Workload Assessment: Subjective Techniques
- Design Guidelines for Human- Computer Interaction
- Cumulative Trauma Disorders in the Workplace
- Shift Work and Sleep Deprivation
- Human Error
- International Anthropometric Data Sources
- Color Coding and Visual Displays

## Previous CUSTOMERS

- NASA
- General Motors Corporation
- AT&T Bell Laboratories
- US Army Tank-Automotive Command
- University of Illinois
- Texas Instruments Inc.
- US Consumer Product Safety Commission
- NCR Corporation
- Naval Air Warfare Center
- Ford Motor Company
- FAA Technical Center
- US Nuclear Regulatory Commission

For More Information Contact:
Mike Gravelle
Senior Technical Analyst
CSERIAC Program Office
(513) 255-4842

# Color in Electronic Displays

**David L. Post**

Color electronic displays are replacing monochrome ones in virtually every application. Consumers rarely buy black-and-white televisions nowadays, and the growing popularity of color-coded graphical user-interfaces for personal computers is causing a similar extinction on our desktops. Monochrome has some niche markets, particularly those requiring the highest possible luminance, resolution, compactness, and/or cost effectiveness; however, the performance of color displays has become satisfactory for most applications and continues to improve while the cost differential for color versus monochrome keeps narrowing and, for many purposes, has become inconsequential already.

It isn't difficult to understand the popularity of color displays. Most of us recognize from personal experience that, when they are designed properly, they are not only more pleasing aesthetically than monochrome displays, but also convey more information and/or do so faster. The catch is that color must be used "properly," and information about how to do this can be hard to find, particularly for non-specialists.

In 1987, NATO formed Research Study Group (RSG) 13 for the purpose of developing and distributing guidance regarding the use of color on electronic displays. During our first meeting, we discussed the fact that, although a tremendous amount of information exists concerning color vision, color perception, colorimetry, and color displays—much of it relevant to display design—it is scattered across numerous texts, journals, conference proceedings, and technical reports. We decided that we could fulfill the RSG's purpose best by producing a book that consolidates and summarizes this information, emphasizing those aspects most applicable to display design. The major intended audience would be engineers, scientists, and designers who wish to work with color displays but are unfamiliar with the underlying science; however, we anticipated that more advanced readers might benefit as well from an up-to-date and comprehensive review.

We developed an outline, recruited authors, reviewed draft chapters, and performed the editing required to turn a collection of manuscripts into a finished book. *Color in Electronic Displays*, published recently by Plenum Press, is the final result. The 335-page book consists of 11 chapters, written by 10 internationally recognized experts (plus myself) covering the physics, psychophysics, and psychophysiology of color information display. It includes 108 figures, 20 tables, 87 equations, and over 900 references, as well as complete subject and author indices.

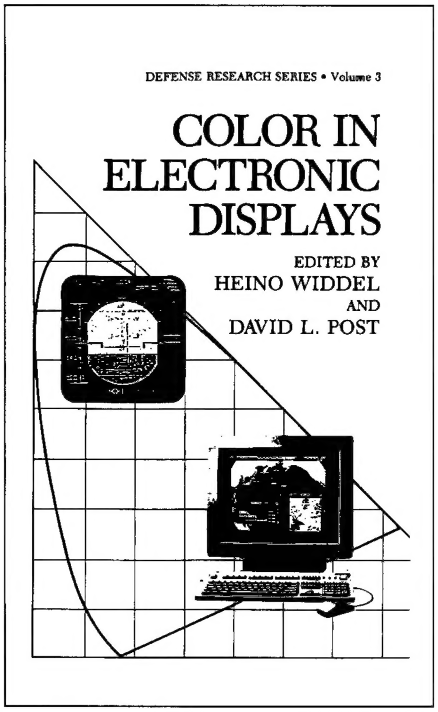
The book is organized in four major sections. The first is intended to acquaint the reader with basic facts concerning color vision, perception, and measurement. Chapter 1.1 (Jan Walraven) discusses the perceptual, psychological, and psychophysical dimensions of color, introduces CIE colorimetry and the notion of color space, describes the basic types of defective color vision and their consequences for display design, and concludes with an example that illustrates the application of this knowledge to the design of a color-coded display. Chapter 1.2 (Terry Benzschawel) explains the CIE system of colorimetry and its origins in detail and then goes on to discuss the CIE uniform color spaces and several important alternatives.

The second section is devoted to research on color vision. Chapter 2.1 (Harry L. Snyder and Leonard J. Trejo) reviews the major psychological, physiological, and behavioral research methods that have been used, discusses their advantages, disadvantages, and interrelationships, describes typical results, and concludes with guidance concerning the use of these methods. Chapter 2.2 (David L. Post) introduces many of the applied problems in color vision that have been investigated and reviews the research findings. Chapter 2.3 (S.M. Luria) focuses on the effects of the environment on color vision and summarizes much of what has been learned to date.

The third section is concerned with the application of color science. Chapter 3.1 (V. David Hopkin) discusses practical issues and problems in the use of color on displays, as well as specific applications, including aircraft cockpits, maps and charts, air traffic control, command and control, and word processing. Chapter 3.2 (J.D. Grossman) reviews conventions that have evolved for the use of color and standards developed by military and civilian organizations.

The last section covers electronic color-display technology. Chapter 4.1 (T.R.H. Wheeler and M.G. Clark) treats CRTs, starting with their history, basic principles of operation, and major applications. The chapter then proceeds to specific designs, including the shadowmask, beam-indexing, beam-penetration, field-sequential, and multi-element array technologies; discusses phosphors and the design of phosphor screens; and concludes with a description of extended and high-definition television and "virtual worlds" displays. Chapter 4.2 (M.G. Clark) explains flat-panel color display technology, including thin CRTs, vacuum fluorescent, plasma, light-emitting diode, electroluminescent, liquid crystal, electrophoretic, electrochromic, and electromechanical designs. Chapter 4.3 (Ronald S. Gold) covers the major types of color projection displays, including those based on CRTs, light valves, and lasers, and concludes with a discussion of projection screens and their impact on the final image. Chapter 4.4 (David L.

*Continued on page 18*




*Color in Electronic Displays (Heino Widdel & David L. Post, Eds., 1992).*

Post) is concerned with measuring and predicting the colorimetric behavior of displays. It treats the design, use, and calibration of colorimetric instruments, calibration of color displays, techniques for predicting a display's color output, and methods for enhancing the accuracy of the predictions.

*Color in Electronic Displays* was edited by Heino Widdel of the Forschunginstitut für Anthropotechnik and me, with Jeffrey D. Grossman of the Naval Ocean Systems Center and Jan Walraven of the Institute for Perception (TNO) as associate editors. CSERIAC is distributing the book through special arrangements with the publisher. It is available for $45. Please contact the CSERIAC Program Office for ordering information. ●

*David L. Post is an Industrial Engineer in the Human Engineering Division of the Armstrong Laboratory, Wright-Patterson Air Force Base, OH.*

**SCOPE** *Continued from page 15*
continue making them available for the HFE and Human Systems Integration (HSI) communities.

SCOPE is being developed under contract with LICA Systems, Inc., Fairfax, VA. It is designed to run on the Macintosh II family of personal computers. Other operating requirements are Macintosh system software, version 6.0 or later, a 13-inch color monitor, a minimum 2 megabytes of RAM, one 3.5-inch floppy drive, a minimum 20-megabyte hard drive, and any word processor written for the Macintosh.●

*Bruce McCommons is an Engineering Psychologist for HEL, Aberdeen Proving Ground, MD. He is the SCOPE functional developer and Contracting Officer's Representative (COR).*

*Bob Cofod is the president of LICA Systems, Inc., Fairfax, VA, the technology and software developer.*

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